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Implementation of K-means algorithm in data analysis

Asyahri Hadi Nasyuha[1], Zulham[2], Ibnu Rusydi [2]
[1] Information of System, STMIK Triguna Dharma, Medan, Indonesia
[2,3] Software Engineering, Faculty of Engineering and Computer Science, Dharmawangsa University, Medan, Indonesia

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ABSTRACT

Some large companies have difficulty in providing products even though the products are still available in the warehouse. Based on these problems, a solution is needed in managing cosmetic products and can find the right strategy so that it can increase business in the field of sales and improve sales services by using algorithms in data mining that can overcome these problems, such as clustering techniques that use the K-means clustering algorithm as a way to measure proximity data between cosmetic products based on transactions that have occurred. The specialty of the analysis of the management of cosmetic products in this study is that it produces data on products that are not sold enough so that it can provide prevention so that the accumulation of these products does not occur. The use of K-means clustering also makes it easier to collect cosmetic sales transaction data, can solve problems in classifying cosmetic product sales transaction data and find out which products should be in cosmetics stock so as to increase sales profits.

Corresponding Author:

Asyahri Hadi Nasyuha
Information of System, STMIK Triguna Dharma
Jl. AH. Nasution No. 73 Medan Johor Medan, Indonesia
Email: asyahrihadi@gmail.com

1. INTRODUCTION

Cosmetics are substances or preparations intended for use on the external parts of the human body (epidermis, hair, nails, lips and external genital organs) or on the teeth and mucous membranes of the mouth, especially to clean, perfume, change appearance and or improve body odor or protect or keep the body in good condition [1]. Cosmetic companies that provide various kinds of cosmetics will always provide various kinds of products and are stored in storage warehouses, so sometimes many products that are difficult to find quickly cannot even be found even though the product is still available in the warehouse. Cosmetic companies are required to find solutions in the management of beauty products (cosmetics) and find strategies that can increase business in the sales sector, especially to improve the best service. That way, cosmetic companies can run their business according to their needs so that they are more efficient and effective in their management, especially for their stock of goods.

Data mining is an extension and branch of statistics data mining is a mining process or the discovery of new information that is done by looking for a certain pattern or rule from a number of data that accumulates and is said to be big data [2], [3]. Data mining can also be interpreted as a process in finding or exploring the value of data in the form of knowledge that has not been known manually, whose knowledge can be useful. It takes data mining techniques such as clustering using the K-means clustering algorithm [4]. In the research of Zhao *et al*. stated that the K-means procedure makes the process of grouping documents, searching for nearest neighbors, and grouping images simpler and converges to a much better local optima [5]. Another analysis states that among many clustering algorithms, the K-means clustering algorithm

is widely used because of its simple algorithm and fast convergence [6]. Clustering technique using the K-means clustering algorithm is a way of measuring proximity data between cosmetic products based on transactions that have occurred. As is known clustering in data mining can be used to analyze the grouping of sales transactions. In the concept of analysis carried out by analyzing the problems and needs in the problems discussed, such as determining the grouping of cosmetic sales transaction data, implementing an analysis that has been tested on the grouping of cosmetic sales data, then an assessment of the indicators of the cause of the problem will be carried out and at the last stage a system design will be carried out so that can solve the problem. The analysis of the management of cosmetic products in this study is to produce product data that is best seller, quite in demand and, less selling well so that it can provide prevention so that the accumulation of these products does not occur.

2. RESEARCH METHOD

Data mining is a mining process or the discovery of new information that is done by looking for a certain pattern or rule from a number of data that accumulates and is said to be big data [7], [8]. Data mining can also be interpreted as a series of processes in finding or exploring added value for data in the form of knowledge that has not been known manually, whose knowledge can be useful [9], [10]. Data mining is not a field that can be said to be new. Data mining is a development and branch of statistics [11], [12]. Therefore, data mining and statistics are closely related to each other. One of the things that makes it difficult to interpret data mining is the fact that data mining inherits many fields, aspects and techniques from other disciplines that have been established beforehand [13], [14].

2.1. K-means clustering

K-means is one of the algorithms used in classifying data, K-means is also one of the algorithms in data mining science [15], [6], [16]. There are many approaches to grouping, one of which is to create rules that read very large data at many levels. In another approach, K-means also creates a set of functions to measure the properties of existing clusters [17], [18]. K-means is a method where the algorithm is distance-based which divides the data into several clusters and this algorithm only works on numeric attributes [19]-[21]. K-means is a distance-based clustering method in dividing data into clusters. This algorithm also works on numeric attributes. Besides, K-means is also included in partitioning clustering which separates data into separate parts so that the data is more grouped [22]. K-means is very popular and easy to use because it has the ability to group large data very quickly [23]. In the K-means method, each data must enter a certain cluster at a stage of the process, at the next stage of the process it can move to another cluster, so that in this method the data can be grouped with their respective clusters.

In the K-means method, each data must belong to a certain cluster at a stage of the process, at the next stage of the process it can move to another cluster. The grouping of data using the K-means method is carried out using the following algorithm [24], [25]:

- Set the desired number of clusters.
- Place data into clusters randomly.
- Calculate the cluster center (centroid/mean) of the data in each cluster. The location of the centroid of each group is taken from the average value (mean) of all data values for each feature. If *M* represents the number of data in a group, *i* represents the *i-th* feature in the group, and *p* represents the data dimension, then the equation to calculate the centroid of the *i-th* feature is (1).

  $$Ci = \frac{1}{M}\sum_{j=1}^{m} X_j \quad (1)$$

  In (1) is carried out as many as p dimensions from $i = 1$ to $i = p$.
- Allocate each data to the nearest centroid/average. There are several ways that can be done to measure the distance of the data to the center of the group, including Euclidean. The measurement of distance in Euclidean distance space can be found using (2).

  $$d = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2} \quad (2)$$

Re-allocate data to each group in the K-means based on the distance between the data and the centroid in each available group. Then the data is distributed accurately to the group that has the cetroid and the closest distance from the data. This data allocation is calculated using (3).

$$a = \{1\ 0\ \frac{d=\{D(x,c)\}}{Lainnya} \tag{3}$$

ai1 is the value of a member with point *xi* to the center of group *c1*, while d is the shortest distance from data *xi* to group *K* that has been compared, while *c1* is the 1st centroid (center of the group). The functions and objectives used in the K-means method are determined based on the distance and the value of data membership in a group. Thus the function and purpose use (4) in calculating it.

$$J = \sum_{i=1}^{n} \sum_{i=1}^{k} Aic\ D(x,c)^2 \tag{4}$$

n is the number of data, *k* is the number of groups, *ai1* is the membership value of the data point *xi* to the group *cl* followed. *a* is 0 or 1. If the data is a member of a group, then the value *ai1 = 1*. Otherwise, the value *ai1* = 0. Then we go back to stage 3, if it is found that there is data that is still moving groups or if there is a change in the centroid value above the specified threshold value, or there is a change in the function value and the objective is still above the predetermined threshold value.

3. RESULTS AND ANALYSIS

System algorithm is the steps taken by a system in processing and solving a problem. The following is a flowchart or flow of problem solving using the K-means method. This stage is carried out by applying the K-means algorithm with the formula [26], [27]:

$$d(x, y)= ||x-y||= \sqrt{\sum_{i=1}^{n} (xi - yi); i = 1,2,3, \ldots\ldots n}$$

The application of the number of clusters (K) is 3 clusters. After setting the number of clusters, determine the initial center point of the cluster (centroid). Some of the selected center points can be seen in Table 1.

Table 1. Initial centroid data

Centroid	Product	Product in	Product sold	Stock
Centroid 1	Garnier	46	11	8
Centroid 2	L'oreal	57	65	9
Centroid 3	Nivea	50	58	6

Calculate the distance of the data to the centroid using the Euclidean formula, the data will be designated as a member of the closest cluster. Calculation of the distance (distance) between variables from each data sample with the centroid is shown in Table 2.

Table 2. Cosmetics data

Product	Incoming product	Product sold	Stock
Wardah	34	23	52

- With centroid 1 (46, 11, 8)
  Distance between Wardah and point C1

$$=\sqrt{\sum_{i}^{n} = 1\ (xi - yi)^2} = \sqrt{(34-46)^2 + (23-11)^2 + (52-8)^2} = 47.15930449$$

- With centroid 2 (57, 65, 9)
  Distance between Wardah and point C2

$$=\sqrt{\sum_{i}^{n} = 1\ (xi - yi)^2} = \sqrt{(34-57)^2 + (23-11)^2 + (52-8)^2} = 64.35837164$$

- With centroid 3(50, 58, 6)
  Distance between Wardah and point C3

$$=\sqrt{\sum_{i}^{n} = 1\ (xi - yi)^2} = \sqrt{(34-50)^2 + (23-58)^2 + (52-6)^2} = 59.97499479$$

Perform the same calculation process up to the 30th object. The results of the iteration 1 calculation can be seen in the Table 3. Where the closest distance is seen from the calculation of the closest to the center of the cluster. While within cluster variation (WCW) is the result of the power of the calculation of the closest distance to the center of the cluster. For more complete distance in each data row, the results are as in Table 3.

Table 3. Iteration 1

Code	Product	C1	C2	C3	Cluster
A001	Wardah	47.1593	64.35837	59.97499	Cluster 1
A002	Emina	45.32108	11.22497	2.236068	Cluster 3
A003	Maybelline	7.28011	50.32892	41.78516	Cluster 1
A004	Garnier	0	55.11806	47.21229	Cluster 1
A005	Make Over	54.01852	12	9.110434	Cluster 3
A006	Viva	42.80187	12.40967	7.549834	Cluster 3
A007	Nivea	47.21229	10.34408	0	Cluster 3
A008	Purbasari	43.0581	14.3527	4.582576	Cluster 3
A009	Sariayu	44	14.89966	5.385165	Cluster 3
A010	Pond's	1	54.92722	47.13809	Cluster 1
A011	Rexona	54.09251	14	10.34408	Cluster 3
A012	Y.O.U	42.09513	17.72005	8.774964	Cluster 3
A013	Marcks	47.42362	9.110434	2	Cluster 3
A014	Pigeon	43.01163	15.68439	5.744563	Cluster 3
A015	Inez	44.55334	10.81665	4.690416	Cluster 3
A016	Pixy	0	55.11806	47.21229	Cluster 1
A017	L'oreal	55.11806	0	10.34408	Cluster 2
A018	Mustika Ratu	46.56179	15.0333	17.23369	Cluster 2
A019	Madam Gie	55.26301	19.54482	25	Cluster 2
A020	M.A.C	47.86439	15	17.49286	Cluster 2
A021	Revlon	45.60702	10.0995	8.774964	Cluster 3
A022	Citra	63.79655	69.78539	65	Cluster 1
A023	Bioaqua	50.69517	71.38627	69.53416	Cluster 1
A024	Fair and Lovely	54.53439	4.472136	9.110434	Cluster 2
A025	La Tulipe	64.16385	47.54997	49.8999	Cluster 2
A026	Olay	47.77028	7.874008	6.403124	Cluster 3
A027	Silkygirl	71.96527	57.10517	59.34644	Cluster 2
A028	Marina	63.00794	47.24405	47.61302	Cluster 2
A029	Lakeme	60.49793	54.49771	53.93515	Cluster 3
A030	Safi	72.86975	56.93856	59.06776	Cluster 2

From Table 3. the membership can be as follows:

- Cluster 1 = {Wardah, Maybelline, Garnier, Pond'S, Pixy, Citra, Bioaqua}
- Cluster 2 = {L'oreal, Mustika Ratu, Madam Gie, M.A.C, Fair and Lovely, La Tulipe, Silkygirl, Marina, Safi}
- Cluster 3 = {Emina, Make Over, Viva, Nivea, Purbasari, Sariayu, Rexona, Y.O.U, Marcks, Pigeon, Inez, Revlon, Olay, Lakeme}

Perform a centroid update from the cluster results as follows:

- Cluster 1 = average (Wardah, Maybelline, Garnier, Pond's, Pixy, Citra, Bioaqua) = (24.27587571, 60.14604044, 53.97956857)
- Cluster2 = average (L'oreal, Mustika Ratu, Madam Gie, M.A.C, Fair and Lovely, La Tulipe, Silkygirl Marina, Safi) = (59.03871667, 29.20977812, 32.78979822)
- Cluster3 = average (Emina, MakeOver, Viva, Nivea, Purbasari, Sariayu, Rexona, Y.O.U, Marcks, Pigeon, Inez, Revlon, Olay, Lakeme) = (47.24738, 15.35955926, 9.252238429)
- The centroid value changes from the previous centroid value, then the algorithm continues to the next step.
- Calculate the distance of the data to the centroid using the Euclidean formula, the data will be designated as a member of the closest cluster.

Next, calculate iteration 2 as well as iteration 1 to get the same ratio value as the previous ratio value. After 3 iterations, the centroid value decreases from the previous centroid value, so the final result in Table 4.

Table 4. Grouping of cluster results

Product	C1	C2	C3	Cluster
Wardah	34	23	52	Cluster-1
Maybelline	42	17	7	Cluster-1
Garnier	46	11	8	Cluster-1
Ponds	47	11	8	Cluster-1
Pixy	46	11	8	Cluster-1
Citra	11	38	54	Cluster-1
Emina	51	56	6	Cluster-2
Make Over	45	65	9	Cluster-2
Viva	54	53	10	Cluster-2
Nivea	50	58	6	Cluster-2
Purbasari	48	54	7	Cluster-2
Sariayu	46	55	8	Cluster-2
Rexona	43	65	9	Cluster-2
Y.O.U	44	53	10	Cluster-2
Marcks	52	58	6	Cluster-2
Pigeon	46	54	7	Cluster-2
Inez	53	55	8	Cluster-2
Loreal	57	65	9	Cluster-2
Mustika Ratu	66	53	10	Cluster-2
Madam Gie	75	58	6	Cluster-2
M.A.C	67	54	7	Cluster-2
Revlon	58	55	8	Cluster-2
Fair and Lovely	53	65	11	Cluster-2
La Tulipe	58	53	55	Cluster-2
Olay	54	58	11	Cluster-2
Silkygirl	55	54	65	Cluster-2
Marina	43	55	53	Cluster-2
Lakeme	44	45	58	Cluster-2
Safi	52	56	65	Cluster-2
Bioaqua	65	11	55	Cluster-3

3.1. Interpretation or evaluation

At this stage, in Table 5, it can be seen the results of the 3rd clustering using the K-means clustering algorithm to measure the best-selling products that must always be in stock. Then in Table 6 it can be seen the results of the second clustering using the K-means clustering algorithm to measure the quite in demand products that must always be in stock. The results of the first clustering with the application of the K-means algorithm showed several products that were less selling, as shown in Table 7.

Table 5. Best selling results

No	Product	Cluster	Description
1	Bioaqua	Cluster-3	Best sellers

Table 6. Results are quite in demand

No	Product	Cluster	Description
1	Emina	Cluster 2	Quite in demand
2	Make Over	Cluster 2	Quite in demand
3	Viva	Cluster 2	Quite in demand
4	Nivea	Cluster 2	Quite in demand
5	Purbasari	Cluster 2	Quite in demand
6	Sariayu	Cluster 2	Quite in demand
7	Rexona	Cluster 2	Quite in demand
8	Y.O.U	Cluster 2	Quite in demand
9	Marcks	Cluster 2	Quite in demand
10	Pigeon	Cluster 2	Quite in demand
11	Inez	Cluster 2	Quite in demand
12	Loreal	Cluster 2	Quite in demand
13	Mustika Ratu	Cluster 2	Quite in demand
14	Madam Gie	Cluster 2	Quite in demand
15	M.A.C	Cluster 2	Quite in demand
16	Revlon	Cluster 2	Quite in demand
17	Fair and Lovely	Cluster 2	Quite in demand
18	La Tulipe	Cluster 2	Quite in demand
19	Olay	Cluster 2	Quite in demand
20	Silkygirl	Cluster 2	Quite in demand
21	Marina	Cluster 2	Quite in demand
22	Lakeme	Cluster 2	Quite in demand
23	Safi	Cluster 2	Quite in demand

Table 7. Less selling

No	Product	Cluster	Description
1	Wardah	Cluster 1	Less selling
2	Maybelline	Cluster 1	Less selling
3	Garnier	Cluster 1	Less selling
4	Ponds	Cluster 1	Less selling
5	Pixy	Cluster 1	Less selling
6	Citra	Cluster 1	Less selling

4. CONCLUSION

Based on the results of data mining analysis with K-means can solve problems in classifying cosmetic product sales transaction data and find out which products must be in cosmetics stock so as to increase sales profits, K-means clustering algorithm for cosmetic clustering product sales transaction data is very effective in solve grouping problems. Analysis of the management of cosmetic products in this study is to produce data on products that are best sellers, are quite in demand and not in demand so that they can provide prevention so that the accumulation of these products does not occur. The K-means algorithm is proven to be effective for product grouping cases, this can encourage other research for different product grouping cases.

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BIOGRAPHIES OF AUTHORS

Asyahri Hadi Nasyuha he received his Doctorate (Doctorate in Vocational Technology Education) at the Faculty of Engineering from Padang State University in 2020. He is a Lecturer in computer science at the Information Systems Study Program, STMIK Triguna Dharma, Medan, Indonesia. In addition, he also serves as Head of the Quality Assurance Institute at STMIK Triguna Dharma. Since 2019, he has a professional lecturer certification from the Ministry of Research, Technology and Higher Education. In 2021 he was assigned by the Ministry of Education, Culture, Research and Technology as a Lecturer Workload Assessor. He is also one of the reviewers of the SINTA 3 indexed national journal. He has published more than 35 journal papers, 3 written books, and 3 papers in conference proceedings. His research interests are Decision Support Systems, Artificial Intelligence, Data Mining. He can be contacted at email: asyahrihadi@gmail.com.

Zulham he received his Doctorate (Doctorate in Vocational Technology Education) at the Faculty of Engineering from Padang State University in 2021. He is a Lecturer in computer science at the Software Engineering Study Program, Faculty of Engineering and Computer Science, Dharmawangsa University, Medan, Indonesia. In addition, he also serves as Head of the Software Engineering Study Program, Dharmawangsa University. Since 2020, he has a professional lecturer certification from the Ministry of Research, Technology and Higher Education. Since 2021 he has been assigned by the Ministry of Education, Culture, Research and Technology as a Lecturer Workload Assessor. He is also active as the manager of several journals at Dharmawangsa University. His research interests are, Data Mining, Artificial Intelligence, and Decision Support Systems. He can be contacted at email: zulham@dharmawangsa.ac.id.

Ibnu Rusydi he received his Master's degree in Computer Science at the Faculty of Computer Science, Department of Computer Science from Putra Indonesia University Padang in 2016. He is a Lecturer in computer science at the Software Engineering Study Program, Faculty of Engineering and Computer Science, Dharmawangsa University, Medan, Indonesia. In addition, he also serves as the manager of the information technology center and database at the State Islamic University of North Sumatera. Since 2019, he has a professional lecturer certification from the Ministry of Research, Technology and Higher Education. He is also active as the manager of several journals at Dharmawangsa University. His research interests are, Data Mining, Artificial Intelligence, and Decision Support Systems. He can be contacted at email: ibnurusydi@dharmawangsa.ac.id.